§ 18. Effects of Impurities on Ignition Condition of D-^{3}He Fueled ST Reactor

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The effects of impurities on the ignition condition of D-^{3}He fueled ST (Spherical Torus) was investigated. In this study the daughter fusion reactions by fusion products, D-T and D-D, are included as well as main fusion reaction of D-^{3}He. In order to obtain the ignition condition, the power balance of ions and electrons and the particle balance of plasma species: D, ^{3}He, p, T, and ^{4}He are considered. As the operation temperature is forecasted of around 100 keV, the Bremsstrahlung radiation power is interpolated to the region about 100 keV from the non-relativistic and the extremely relativistic one, where the quadrupole radiation due to electrons themselves can not be neglected (Fig.1).

The ignition conditions is shown in Fig.2 in case of spatial averaged beta value = 0.4, aspect ratio of plasma = 1.5, synchrotron reflection coefficient of metallic wall = 0.8 and fuel ion density ration $n_D / n_{3He} = 2.0$. It was found that effective atomic number Z_{eff} larger than 2.12 gives no ignition condition, which is compared to 1.76 without impurities. The value 2.12 of Z_{eff} corresponds to the 2.2 % of carbons to electrons. The operating plasma temperature is as high as around 50 keV.

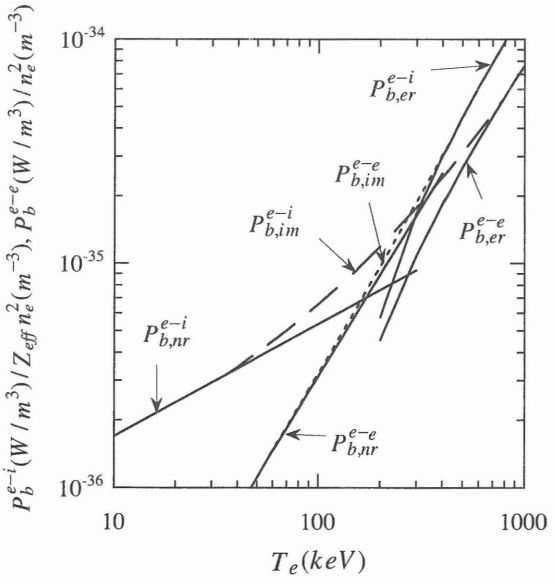

Fig. 1. Bremsstrahlung radiation power as a function of electron temperature due to electrons and ions (e-i) and electrons (e-e) in the region of non-relativistic (nr), intermediate (im), and extremely relativistic (er) temperature.

The ignition parameter $n_e \tau_\varepsilon$ is required from 1.0×10^{21} m^{-3} sec up to 3.0×10^{21} m^{-3} sec due to the effects of impurities, where n_e and τ_ε are the electron density and the required energy confinement time, respectively. The neutron power production (P_n) to fusion power (P_f), however, increases only 30 % compared to case of impurity free.

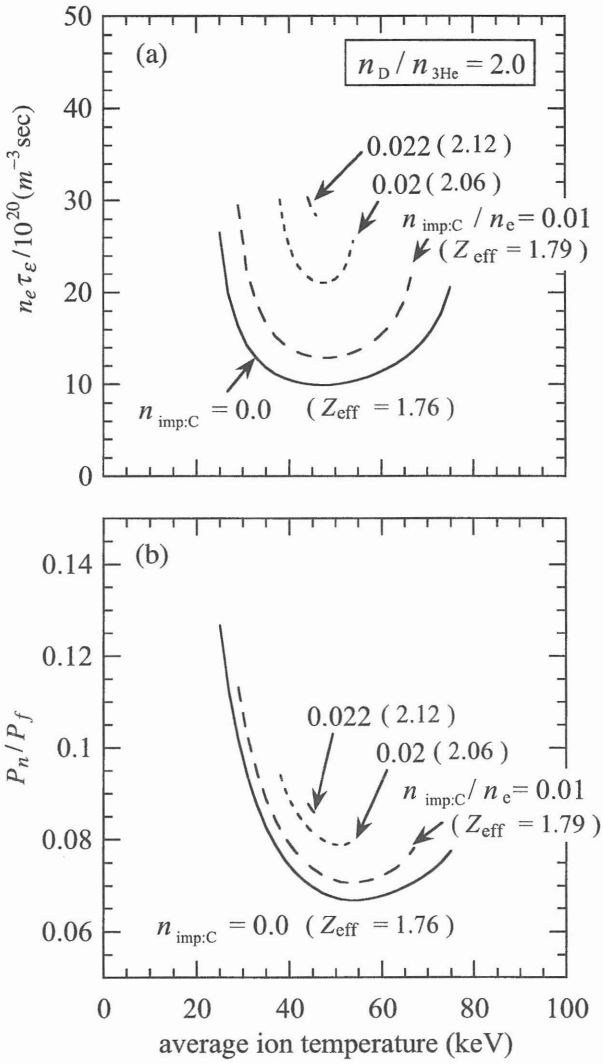

Fig. 2. The required ignition parameter $n_e \tau_\varepsilon$ (a) and power ratio of neutron to fusion P_n / P_f (b) as a function of spatially averaged ion temperature. The higher impurity density than 0.02 gives no ignition.